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TITLE: Rail Road Car with Cantilevered Articulation

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TO ALL WHOM IT MAY CONCERN:

BE IT KNOWN THAT I, James W. Forbes

of 15 Glenron Road, R.R. #2, Campbellville, Ontario, Canada L0P 1B0,

Citizen of Canada,

have invented a : **RAIL ROAD CAR WITH CANTILEVERED ARTICULATION**

of which the following is a specification.

RAIL CAR WITH CANTILEVERED ARTICULATION

FIELD OF THE INVENTION

This invention relates generally to articulated rail road cars.

BACKGROUND OF THE INVENTION

The dimensions of rail road cars are constrained by a number of geometric considerations. First, on tangent track (that is, straight track) a rail road car can not be too wide, otherwise it may foul the sides of bridges, tunnels, roadside fittings such as switches or signals, or other cars of the same size passing on an adjacent track. Similarly, rail cars cannot be taller than the minimum regulated heights of the lowest bridges or tunnels on the tracks along which it is to travel. Third, the weight a car can carry is limited by the capacity of the tracks, rails and road bed over which it is to travel.

With reference to Figures **1a**, **1b**, **1d** and **1e**, on curved track, the relationship between length and width is important. Traditionally, single unit rail road cars **A20** have had a car body supported by a rail car truck **A22**, **A24** at either end. The mounting to a standard two axle, four wheel truck is at a pivot at the truck center, **A26**. The cars are connected at a releasable coupler **A28** in the commonly known manner. When such a car passes through a curve trucks **A22**, **A24** follow the arc indicated by the track centerline, S_1, while the car body centerline between the truck centers forms a chord κ of the arc. Chord κ subtends an angle α_1 of arc S_1. This is shown , with exaggerated proportions, in Figure **1a**. The track center line radius is indicated as R_1. At midspan between the trucks, the inside edge of the car follows a circular arc having a radius of curvature indicated as the limiting inside minimum radius R_2. Car **A20** is shown as having overhanging end portions **A30** and **A32** that extend longitudinally outboard of the respective truck centers. As car **A20** passes through a curve the extreme outside corners of end portions **A30** and **A32** will follow along an outer radius, namely the limiting minimum outside radius indicated as R_3.

For any curve, the longitudinal center line of the car, **CL**, at mid-span between the trucks will lie some distance, δ, inward from the center of the track, as indicated by δ_1. This distance δ depends on the radius of curvature, R_1 of the tracks, and the distance between truck centers, L_1. As shown in Figure **1a**, for a given dimension L_1, δ increases as the radius of curvature decreases, as indicated by R_4. Alternatively, for a fixed track

radius $\mathbf{R_1}$, as the truck center distance $\mathbf{L_1}$ increases, δ also increases. The left hand example of Figure **1a** demonstrates this. For a track having a radius of curvature $\mathbf{R_4}$, the arc is identified as $\mathbf{S_2}$. Placing two of rail road cars **A20** on this track, the chord length remains κ but the subtended angle, α_2, is larger than α_1, and the distances between the inner and outer clearance radii, $\mathbf{R_5}$ and $\mathbf{R_6}$, is greater than between $\mathbf{R_2}$ and $\mathbf{R_3}$, with a consequent increase in δ form δ_1 to δ_2.

In North American service, the relationship of rail road car width and length, and the corresponding necessary reductions in width required as truck center distance increases are set out by the American Association of Railroads (AAR) in various AAR standards. Cars to be used in interchangeable service are required to conform to the AAR standards. For all cars, including AAR plate 'C' cars, the limiting centerline track radius, $\mathbf{R_1}$, is a standard minimum dimension of 5300.375 inches. For plate 'C' cars, the limiting minimum inside radius, $\mathbf{R_2}$, is determined on the basis of a car ("the base car") having a truck center spacing of 46' - 3" (555 inches), and a maximum car width of 10' - 8" (128 inches). For this standard car, δ_1 is roughly 7.25 inches, so $\mathbf{R_2}$ is roughly 5229.12 inches. For plate 'C' cars the limiting minimum outside radius, $\mathbf{R_3}$, is defined as being greater than $\mathbf{R_1}$ by the same amount as $\mathbf{R_2}$ is less than $\mathbf{R_1}$. Thus, adding the 7.25 inch offset, plus half of the car width, namely 64 inches, gives an $\mathbf{R_3}$ of 5371.63 inches.

If car **A20** is not to foul adjacent cars or adjacent structures while passing through curves, as the truck center length increases beyond 46' - 3", the width of the car must decrease correspondingly so the inside of the car at mid-span between the trucks of the car does not cut to the inside of $\mathbf{R_2}$. The allowable width of a car for a given truck center distance can be calculated from this datum case. A different standard applies for auto-rack rail road cars, but the principles are the same. In AAR specification M-950-A-99, the maximum width of a bi-level auto-rack car having a length of 90' over the strikers is given as 119" at mid span, and 121" at the strikers. Typically such an auto-rack has truck centers on either 64' or 66' spacing. The limiting minimum inside radius, $\mathbf{R_2}$, for this car is 5226.06 inches and the limiting minimum outside radius, $\mathbf{R_3}$, is 5373.27". The outside extreme corners **A30**, **A32** must stay within $\mathbf{R_3}$. In some cases, for long overhangs, the ends of the car must be narrowed.

Similarly, some types of inter-modal well cars are used for carrying containers, or for carrying highway trailers or a combination of the two. The well must be wide enough to accommodate either the highway trailers or the containers, as may be required. Center

beam cars, such as are commonly used for carrying stacked bundles of lumber must have wide enough bunks to carry standard widths of bundles.

Auto-rack rail road cars must be wide enough not only to carry automobiles, but they also must be wide enough to allow space for persons loading and unloading the automobiles to open the automobile doors and get in and out of the automobiles. The person loading the automobiles must also have sufficient space to walk beside the automobiles. When the clearance allowed is too small, the loading personnel may inadvertently damage the finish of the automobiles, giving rise to damage claims. Alternatively, it may be that it is helpful, or necessary, to allow a clearance envelope to accommodate motion of the lading during travel. In each case, it is helpful to lengthen the car to increase lading, but such lengthening is limited by the need to maintain a car body width.

Conventionally, articulated rail road cars have two or more rail car units permanently connected to each other such that one rail car truck is shared between two adjoining rail car units. Typically, an articulated rail road car having a number of rail car units '*n*' is supported on '*n* + 1' trucks. An articulation connection is a permanent connection unlike a hitch or standard releasable coupling that can be coupled and uncoupled each time a new train consist is made up in a shunting yard. By contrast, an articulated connector, once assembled, tends only to be taken apart during repair or replacement at a workshop, and is considered a permanent connection.

In Figure **1b**, an articulated rail road car **B20** has first and second rail car units **B22** and **B24**. They are joined at their respective inboard ends **B26** and **B28** by an articulation connection **B30** mounted directly above the truck center of a four wheel truck **B32** that is shared between units **B22** and **B24**. The track radius is shown as $\mathbf{R}_1$. The allowable inside radius is shown as $\mathbf{R}_2$. The allowable outside radius is shown as $\mathbf{R}_3$. The extreme corners of outboard ends **B34** and **B36** fall just within radius $\mathbf{R}_3$. When articulated truck **B32** is used, while the inside of the body of car **B20** is tangent to radius $\mathbf{R}_2$, there is clearance between the outermost extremities of inboard ends **B26** and **B28**. This occurs because truck **B32**, is constrained to follow the tracks, and there is no overhang of either unit **B22** or unit **B24** at truck **B32** comparable to the overhang at each of the outboard ends **B34** and **B36**.

Further, in the example of Figure **1b**, a vertically downward shear load is passed

from each of car units **B22** and **B24** into articulation connection **B30**, and then directly into the truck bolster of truck **B32**. That is, each of the car units **B22** and **B24** approximates a span having a simple support at each end into which the vertical shear load, but no bending moment, is passed for reaction through the trucks, and ultimately, by the road bed lying underneath the rails. It will be appreciated that in a multi-unit articulated car having three or more car units, at least one unit will have an articulation connection under both ends.

Figure **1d** shows a three-unit articulated rail road car **C20**, having a middle rail car unit **C22** and end rail car units **C24** and **C26**. As in Figure **1b**, rail road car **C20** is shown on a section of track having centerline radius $\mathbf{R_1}$, minimum inside clearance radius $\mathbf{R_2}$, and minimum outside clearance radius $\mathbf{R_3}$. As before, the truck center distance is $\mathbf{L_1}$, and the mid-span lateral inset of the longitudinal centerline of rail car unit **C22** (and, in this example, also of rail car units **C24** and **C26**), is again δ_1. As above, car unit **C22** is joined to car units **C24** and **C26** by respective articulated connectors **C28** and **C30** whose points of articulation lie directly above corresponding shared trucks **C32** and **C34**. It can be seen that the outside corners **C36** and **C38** of car unit **C22**, and corners **C40** and **C42** of car units **C24** and **C26** lie well inward of outside radius $\mathbf{R_3}$.

The rail road cars shown in Figures **1a**, **1b** and **1d** have pivoting, two axle, four-wheel trucks that pivot relative the longitudinal centerlines of the respective car bodies. This permits the truck to run along the arc while the car body forms a chord of the arc, the chord meeting the track centerline at an angle. Single truck railcars are known, particularly in light-weight service as for passenger car train sets where the individual axle loading levels tend to be low relative to the customary load limits of freight cars. The use of single axle trucks in an articulated freight car may tend to be disadvantageous. First, a single axle truck is generally fixed relative to the car body. If allowed to pivot freely in the manner of a double axle truck, a single axle truck would not necessarily continue to follow the rails. However, as car length increases, fixed orientation single axle trucks face an increasing angle of attack relative to the rails when running through a curve. Consequently, single axle trucks tend not to be recommended for rail cars having a separation of more than about 39 feet between trucks. However, the issue of having to reduce the width of the rail road car occurs when the truck centers are already more than 46 ft. 3 in. apart. Second, a single axle truck cannot, in general, carry the same load as a double axle truck having comparable wheels. While single axle trucks may be suitable for the carriage of short, light passenger cars, the length and greater lading of freight cars tends to require double axle trucks.

As noted, in the arrangement shown in Figure **1b**, the articulated rail car units are able to pivot relative to the shared truck, and relative to each other. There is a permanent articulated connector, having a male member and female socket. The articulated connector has a pivot axis that is generally located directly above the center of the shared truck, such that the pivot point of the socket is coincident with the truck center when viewed from above. In this type of arrangement, the pivot point tends always to lie directly above the centerline of the track. One type of articulated connector is shown in U.S. Patent 4,336,758 of Radwill, issued June 29, 1982, in which the main pin is nominally vertical. Another type of articulation connection is shown in U.S. Patent 5,271,511 of Daugherty, Jr., issued Dec. 21, 1993 in which a main pin, in the nature of a removable shaft, is nominally horizontal.

One advantage of articulated connections is that they tend to take up less longitudinal space than common interchangeable couplers. In one application, a number of large automobile manufacturing facilities have a loading siding length that is chosen to handle a string of cars, whether articulated or otherwise, or some combination thereof, up to a limit of 500 ft. in length. One automobile manufacturer would like to be able to load 4 automobiles of a type having a length of 239" (or less), or five compact automobiles on a single auto rack car, or, in the case of an articulated car, on a single car unit. When standard releasable couplers are used on stand alone cars, a 500 ft siding can accommodate 5 rail cars with an overall length of roughly 470', with a total capacity on a single deck level of 20 automobiles of 239 inch length each. A pair of three-pack articulated rail road cars made according to the present invention may tend to permit a six unit rail road car to be accommodated on a 500 ft siding with a total capacity on a single deck level of 24 automobiles of 239 inch length each.

Another advantage is that articulated couplers tend to be slackless couplers. This tends to reduce the longitudinal shock load transmitted during run-in and run-out, and during shunting. Other types of slackless coupling exist other than articulated couplings. For example, it is possible to use a draw bar between cars, as shown, for example, in U.S. Patent 4,929,132 of Yeates et al., issued May 29, 1990.

A draw bar is a bar of fixed length that is connected at pivot points at either end to adjacent rail car units on either side. A draw bar reduces the clearance required between the car units as compared to releasable couplers, but cannot be used to transmit a shear load. That is, it may not tend to be advantageous to try to pass a vertical shear load

through a draw bar. Thus use of a draw bar rather than an articulated connector generally requires that there be an adjacent truck mounted to each of the rail car units, with the consequent increase in weight, length, maintenance, and expense.

SUMMARY OF THE INVENTION

In an aspect of the invention there is an articulated rail road freight car having first and second rail car units connected at a cantilevered articulation.

In an additional feature of that aspect of the invention, each of the first and second rail car units has at least one deck upon which vehicles can be loaded. In another additional feature, the freight car has at least one member mounted to permit vehicles to be conducted between said first and second rail car units. In another additional feature, the freight car is an auto rack car having bridge plates mounted to permit automobiles to be conducted between rail car units. In another feature, the freight car is a three pack rail road car having a two truck middle unit and a pair of single truck end units.

In another aspect of the invention, there is an articulated rail road car having a plurality of rail car unit bodies carried on a plurality of rail car trucks, the rolling direction of the rail road car defining a longitudinal direction, the plurality of rail car bodies including a first rail car unit body and a second rail car unit body connected together at an articulation connection, the rail car trucks including a first rail car truck located closer to the articulation connection than any other, the first rail car truck being pivotally mounted to the first rail car body, and the articulation connection being eccentrically mounted relative to the first truck. In an additional feature of that aspect of the invention, the truck is a two axle truck mounted to pivot about a vertical truck center axis relative to the first car body, and the articulation connection is cantilevered longitudinally relative to the truck center.

In another aspect of the invention, there is an articulated rail road car, the car having a rolling direction defining a longitudinal direction on tangent track. The rail road car has first and second rail car units, and a plurality of rail car trucks upon which the railroad car is carried. The first and second rail car units are connected at an articulation connection. One of the rail car trucks is closest to the articulation connection, the closest rail car truck being mounted to the first rail car unit, and the articulation connection is mounted longitudinally eccentrically relative to the closest rail car truck.

In an additional feature of that aspect, the closest rail car truck is a two axle truck. In another additional feature, the first rail car unit has a body, and the closest rail car truck is mounted to pivot about a vertical truck center axis relative to the body of the first rail car unit. In another additional feature, the articulated connection has a first portion mounted to the first rail car unit, and a mating second portion mounted to the second rail car unit, the first and second portions meeting on a bearing interface defining a portion of a spherical surface. In still another additional feature, the articulation connection has a first portion rigidly mounted to the first rail car unit, and a mating second portion mounted to the second rail car unit, the articulation connection being capable of transferring a vertical shear load from the second portion to the first portion.

In another aspect of the invention, there is an articulated rail road car, the rail road car having a rolling direction on tangent track defining a longitudinal direction. The articulated rail road car includes first and second rail car units joined at an articulated connection. The first rail car unit has a first end proximate to the articulated connection, and a second end distant from the articulated connection. The first car unit has a first rail car truck pivotally mounted thereunder. The first rail car truck is located closer to the first end of the first rail car unit than to the second end of the first rail car unit, and the articulated connection is longitudinally eccentric relative to the first rail car truck.

In an additional feature of that aspect of the invention, the second rail car unit has a first end proximate to the articulated connection, and a second end distant from the articulated connection. The second rail car unit has a second rail car truck mounted thereunder. The second rail car truck is located closer to the second end of the second rail car unit than to the first end of the second rail car unit, and the second rail car unit is free of rail car trucks between the articulation connection and the second rail car truck. In a further additional feature, the articulation connection is a first articulation connection, and the rail road car has a third rail car unit joined to the second rail car unit at a second articulation connection.

In a further feature, the second articulation connection is mounted eccentrically relative to the second rail car truck. In still another additional feature, one articulation connection is a first articulation connection. The rail road car has a third rail car unit joined to the second rail car unit at a second articulation connection. The third rail car unit has a first end proximate to the second articulated connection, and a second end

distant from the second articulated connection. The third car unit has a second rail car truck mounted thereunder, the second rail car truck being located closer to the first end of the third rail car unit than to the second end of the third rail car unit, and the second articulated connection is longitudinally eccentric relative to the second rail car truck.

In another additional feature, the rail road car is free of trucks between the first articulation connection and the second articulation connection. In still another feature the rail road car is free of trucks between the first and second trucks. In a further feature, the first rail car unit is supported by a second rail car truck, and the second rail car truck is located closer to the second end of the first rail car unit than to the second end of the first rail car unit. In still another feature, the articulation connection is a first articulation connection, and the rail road car includes a third rail car unit joined to the second end of the first rail car unit at a second articulation connection. In a still further feature, the second rail car truck is mounted underneath the first rail car unit, and the second articulation connection is longitudinally eccentrically located relative to the second rail car truck. In yet another additional feature, the first car unit is the middle car unit of a three unit pack. In another additional feature, the second and third rail car units each have a near end proximate to the first car unit, and a far end distant from the first car unit, and each of the second and third car units is supported by a respective rail car truck mounted closer to the far end than to the near end thereof.

In an additional feature of the invention, the rail car truck has a first pair of wheels mounted on a first axle, and a second pair of wheels mounted on a second axle. The first axle is longitudinally outboard relative to the second axle, and the articulation connection is longitudinally outboard relative to the first axle. In another additional feature, the first car unit has side bearing arms extending from the first end thereof toward the second car unit, and the second car unit has side bearing arms extending therefrom to engage the side bearing arms of the first car unit. In a further additional feature the side bearing arms of the first car unit have bearing surfaces facing upward, and the side bearing arms of the second car unit have bearing surfaces facing downward.

In another additional feature the first car unit has a main bolster mounted over the first truck, and a center sill extending longitudinally outboard therefrom. The center sill has a distal end longitudinally distant from the main bolster, and the articulation connection is mounted to the distal end of the center sill. In still another feature, the center sill is a stub sill. In a further additional feature, first rail car unit has a well

intermediate the first and second ends thereof.

In an alternate additional feature, the first unit has a main bolster mounted above the first truck, a center sill extending longitudinally outboard of the first truck toward the second rail car unit. An endmost lateral structural member, (whether an end bolster or and end sill), extends transversely relative to the center sill, the endmost lateral structural member being located longitudinally outboard of the main bolster, and the center sill has a distal end outboard of the endmost lateral structural member to which the articulation connection is mounted. In an additional feature, the first car unit has longitudinally extending members located transversely outboard and to either side of the center sill. The longitudinally extending members run between the main bolster and the endmost lateral structural member. The longitudinally extending members extend longitudinally beyond the endmost lateral structural member to define a first pair of side bearing arms. The second car unit has a second pair of side bearing arms mounted thereto, located to engage the first pair of side bearing arms.

In another additional feature, the first car unit has longitudinally extending side sills connected to the main bolster and the end bolster. The first car unit has longitudinally extending members each located intermediate the center sill and a respective one of the side sills. The longitudinally extending members run between the main bolster and the end bolster. The longitudinally extending members extend longitudinally outboard beyond the end bolster to define a first pair of side bearing arms; and the second car unit has a second pair of side bearing arms mounted thereto, located to engage the first pair of side bearing arms.

In another aspect of the invention there is an articulated rail road car having first and second rail car units joined at an articulation connection. The first rail car unit has a first end proximate the articulation connection and a second end distant from the articulation connection. The first rail car unit is mounted upon a pair of first and second rail car trucks located under the first and second ends of the first rail car unit respectively and being pivotable relative thereto about truck center axes. The first rail car unit has a pair of first and second main bolsters located at either end thereof, the main bolsters being mounted over the first and second rail car trucks respectively. The rail car has structure connected to maintain the main bolsters in position relative to each other. The first rail car unit has a center sill extending outboard of the first main bolster toward the second rail car unit, the center sill having an outboard end. The articulation connection is

mounted to the outboard end of the center sill.

In an additional feature of that aspect of the invention, the second rail car unit has a first end proximate the articulation connection and a second end distant from the articulation connection. The second rail car unit is mounted upon a third rail car truck located under the second end of the second rail car unit, and the second rail car unit is free of trucks between the third rail car truck and the articulation connection. In an additional feature of that additional feature, the articulated connection is a first articulation connection. The rail road car has a third rail car unit connected to the second rail car unit at a second articulation connection. The second rail car unit has a main bolster mounted above the third rail car truck. The second rail car unit has a center sill extending outboard of the third rail car truck toward the third rail car unit. The center sill of the second rail car truck having a distal end distant from the third truck, and the second articulation connection is mounted to the distal end of the center sill of the second rail car unit.

In another additional feature, the third rail car unit has a first end proximate the second articulation connection and a second end distant from the second articulation connection. The third rail car unit is mounted upon a fourth rail car truck located under the second end of the third rail car unit, and the third rail car unit is free of trucks between the fourth rail car truck and the second articulation connection.

In another additional feature, the articulation connection is a first articulation connection, the outboard end of the center sill is a first end thereof, and the rail road car has a third rail car unit connected to the second end of the first rail car unit at a second articulation connection. In still another additional feature, the center sill is a through center sill having a second end located outboard of the second main bolster, and the second articulation connection is mounted to the second end of the center sill.

In a still further additional feature, the third rail car unit has a first end proximate the second articulation connection and a second end distant from the second articulation connection. The third rail car unit is mounted upon a fourth rail car truck located under the second end of the third rail car unit, and the third rail car unit is free of trucks between the fourth rail car truck and the second articulation connection.

In another aspect of the invention, there is an articulated rail road car having a number of rail car units. The units include at least a first rail car unit, a second rail car

unit, and a third rail car unit, the second rail car unit lying between the first and third rail car units. The articulated rail road car has a number of rail car trucks mounted to support the rail car units, the number of rail car trucks being equal to the number of rail car units plus one. The first rail car unit is connected to the second rail car unit at a first articulation connection. The second rail car unit is connected to the third rail car unit at a second articulation connection. None of the rail car trucks is mounted centrally under either of the first and second articulation connections.

In an additional feature of that aspect of the invention, the rail road car is free of trucks between the first and second articulation connections. In a further feature, each of the first and second rail car units is supported by a spaced apart pair of the rail car trucks mounted thereunder. In a still further feature, each of the first and third rail car units has a cantilever member extending toward the second rail car unit, and the first and second articulation connections are mounted respectively to the cantilever members of the first and third rail car units. In a still further feature, a fourth rail car unit is connected to the third rail car unit at a third articulated connection. The third rail car unit has a first end adjacent the second articulation connection and a second end adjacent the third articulation connection. The first rail car unit is supported by a pair of the rail car trucks, namely first and second spaced apart rail car trucks mounted thereunder. A third one of the rail car trucks is mounted under the first end of the third rail car unit. In still another feature, a fourth rail car unit is connected to the first rail car unit at a third articulated connection. A fifth rail car unit is connected to the third rail car unit at a fourth articulated connection. The first rail car unit has a first end adjacent the first articulation connection and a second end adjacent the third articulation connection. The third rail car unit has a first end adjacent the second articulation connection and a second end adjacent the fourth articulation connection. A first of the rail car trucks is mounted under the first end of the first rail car unit. A second of the rail car trucks is mounted under the first end of the third rail car unit.

In a still further aspect of the invention, there is an articulated rail road car wherein, when standing on tangent track, the rail road car has a first rail car unit and a second rail car unit. The first and second rail car units are joined at an articulated connection. Each of the first and second rail car units has a proximal end near the articulated connection, and a distal end lying far from the articulated connection. The distal end of the first rail car unit is supported by a first rail car truck. The distal end of the second rail car unit is supported by a second rail car truck. A third rail car truck is

mounted to the rail road car between the first and second trucks. The rail road car is free of trucks between the first and second trucks other than the third truck. The third truck is spaced from the first truck a first distance, $\mathbf{D_1}$. The articulation connection is spaced from the first truck a second distance, $\mathbf{D_2}$. The first distance, $\mathbf{D_1}$, is less than the second distance, $\mathbf{D_2}$.

In an additional feature of that aspect of the invention, the third truck is spaced from the second truck a third distance, $\mathbf{D_3}$, and $\mathbf{D_3}$ is different from $\mathbf{D_1}$. In a further feature, $\mathbf{D_3}$ is greater than $\mathbf{D_1}$. In an alternative feature, the third truck is spaced from the articulated connection a third distance, $\mathbf{D_3}$. The second truck is spaced from the articulated connection a fourth distance, $\mathbf{D_4}$, and $\mathbf{D_4}$ is greater than $\mathbf{D_3}$. In a further feature, the third rail car truck is pivotally mounted to the first rail car unit and the first distance, $\mathbf{D_1}$;, is greater than 46 ft. - 3 in.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure **1a** shows a conceptual top view of two rail road cars on curved tracks;

Figure **1b** shows a conventional two-unit articulated rail road car on a curved track;

Figure **1c** shows a conceptual top view of a two unit articulated rail road car according to the present invention, on a curved track;

Figure **1d** shows a conventional three-unit articulated rail road car on a curved track;

Figure **1e** shows a three unit articulated rail road car, an alternative to the two-unit articulated rail road car of Figure 1c, on curved track;

Figure **1f** is a comparison view of the three unit articulated rail road cars of Figures **1d** and **1e**;

Figure **1g** is a conceptual view of a part of the rail road car of Figure **1d**;

Figure **1h** is a further conceptual view of the rail road car of Figure **1d**;

Figure **2a** shows a side view of the two unit articulated rail road car of Figure **1c** as on straight track;

Figure **2b** shows a top view of the rail road car of Figure **1c** as on straight track;

Figure **2c** shows a cross-section of an illustrative articulated connector suitable for use the articulated rail road car of Figure **2a**;

Figure **3a** shows a side view of a three unit articulated rail road car, being an alternate embodiment of articulated rail road car to that of Figure **2a**;

Figure **3b** shows a side view of an alternate three unit rail road car to Figure **3a**;

Figure **3c** shows a side view of another alternate three unit rail road car to Figure **3a**;

Figure **4a** shows a side view of a four unit articulated rail road car, being an alternate embodiment of articulated rail road car to that of Figure **2a**;

Figure **4b** shows a side view of an alternate four unit articulated rail road car to the articulated rail road car of Figure **4a**;

Figure **4c** shows a side view of another alternate four unit articulated rail road car to the articulated rail road car of Figure **4a**;

Figure **4d** shows a side view of a further alternate four unit articulated rail road car to the articulated rail road car of Figure **4a**;

Figure **5a** shows a side view of a five unit articulated rail road car, being an alternate embodiment of articulated rail road car to that of Figure **2a**;

Figure **5b** shows a side view of an alternate five unit articulated rail road car to the articulated rail road car of Figure **5a**;

Figure **5c** shows a side view of another alternate five unit articulated rail road car to the articulated rail road car of Figure **5a**;

Figure **5d** shows a side view of a further alternate five unit articulated rail road car to the articulated rail road car of Figure **5a**;

Figure **5e** shows a side view of still another alternate five unit articulated rail road car to the articulated rail road car of Figure **5a**;

Figure **6a** shows a side view of a two unit articulated auto-rack rail car having the truck layout of the articulated rail road car of Figure **2a**;

Figure **6b** shows a side view detail of the auto-rack rail road car of Figure **6a**;

Figure **6c** shows a top view detail of the auto-rack rail road car of Figure **6a**;

Figure **6d** shows a cross-section at the main bolster of the auto rack rail road car of Figure **6a**;

Figure **6e** shows an alternate cross-sectional view to that of Figure **6d**;

Figure **6f** shows an alternate two unit articulated autorack rail road car to that of Figure **6a**, the rail car units thereof having depressed center portions;

Figure **7a** shows a side view of a three unit articulated auto-rack rail road car having the truck layout of the articulated rail road car of Figure **3c**;

Figure **7b** shows a side view of an alternate three unit rail road car to Figure **7a**;

Figure **8a** shows a side view of a four unit articulated rail road car analogous to the two unit articulated rail road car of Figure **6a**;

Figure **8b** shows a side view of an alternate four unit articulated rail road car to the articulated rail road car of Figure **8a**;

Figure **9a** shows a shortened top view of an articulated well car end unit analogous to an end unit of the two unit articulated rail road car of Figure **2a**;

Figure **9b** shows a shortened side view of the articulated well car end unit of Figure **9a**;

Figure **9c** shows a shortened view of a mating articulated well car end unit to the end unit of Figure **9a**; and

Figure **9d** shows a side view of the shortened end unit of Figure **9c**.

DETAILED DESCRIPTION OF THE INVENTION

The description which follows, and the embodiments described therein, are provided by way of illustration of an example, or examples of particular embodiments of the principles of the present invention. These examples are provided for the purposes of explanation, and not of limitation, of those principles and of the invention. In the description which follows, like parts are marked throughout the specification and the drawings with the same respective reference numerals.

In terms of general orientation and directional nomenclature, for each of the rail road cars described herein, the longitudinal direction is defined as being coincident with the rolling direction of the car, or car unit, when located on tangent (that is, straight) track. In the case of a car having a center sill, whether a through center sill or stub center sill, the longitudinal direction is parallel to the center sill, and parallel to the side sills, if any. Unless otherwise noted, vertical, or upward and downward are terms that use top of rail **TOR** as a datum. The term lateral, or laterally outboard, refers to a cross-wise distance or orientation relative to the longitudinal centerline of the rail road car, or car unit, indicated as **CL - Rail Car**. The term "longitudinally inboard", or "longitudinally outboard" is a lengthwise distance taken relative to a mid-span lateral section of the car, or car unit.

An articulated rail car is indicated in Figure **1c** and Figures **2a** and **2b** generally as **20**. Car **20** is preferably an auto-rack rail road car, but could be another type of rail road freight car, such as a well car, a gondola car, a center-beam car, a spine car, a flat car, a box car, or other type of rail road car. It has a first rail car unit **22** and a second rail car unit **24**. They are joined by a connection that may be conceptually idealised as a pin joint capable of transferring a longitudinal axial load and a shear load in any of two axes, but not a bending moment, in the nature of an articulation connection **26** located between units **22** and **24**. First rail car unit **22** has a pair of first and second ends, **28** and **30**, that are, respectively, proximate to and distant from articulation connection **26**. Second rail car unit **24** has two

ends, **32** and **34** that are, similarly, proximate and distal ends respectively relative to articulation connection **26**. Rail car unit **22** is carried upon, and supported by, two longitudinally spaced rail car trucks **36** and **38** that are located under respective first and second ends **28** and **30**. The nominal vertically extending pivot axis of articulation connection **26** is indicated as a centerline, '**CL - Pivot**'. The truck centers are each indicated as '**CL - Truck**'. The mid-span centerline of unit **22** is indicated as '**CL - Transverse**'.

Second rail car unit **24** is supported at its distal end on a single truck **40**, located under distal end **34**. That is, truck **40** is located closer to distal end **34** of rail car unit **24**, than to proximal end **32** of rail car unit **24**. Support for proximal end **32** is provided through articulation connection **26**. Notably, articulation connection **26** is not mounted directly upon, or above, a truck, but rather is carried at the end of a cantilever **41** extending longitudinally from truck **36** toward rail car unit **24**. As can be seen, rail road car **20** is free of trucks between truck **36** and truck **40**, and hence between articulation connection **26** and truck **40**.

Each of trucks **36**, **38** and **40** is a double axle truck of customary North American construction, having a truck bolster extending perpendicular to the rail road track, a pair of side frames mounted to the laterally outboard ends of the bolster, and two pairs of wheels, each pair of wheels being mounted on a respective one of a pair of spaced apart axles carried in the side frames. Each of trucks **36**, **38** and **40** is free to pivot, or swivel, about the vertical axis of the truck center relative to the body of its respective rail car unit generally, as may be determined by its path along the rails. For example, truck **36** has two axles, a first axle **42** and a second axle **44** spaced equally to either side of the truck center. Axle **42** lies longitudinally inboard of axle **44** relative to the body **46** of first car unit **22**. Car body **46** has an overhanging portion **48** extending outboard of the truck center of truck **36**, between truck **36** and articulation connection **26**. Other types of truck are known, such as three axle trucks and single axle trucks, and could be used in place of truck **36**. Steerable trucks are a included among the other types of trucks.

For the purposes of the present description, unless otherwise stated, distances are measured between the various pivot and truck centers. The distance between the truck centers of trucks **36** and **38** is indicated in Figure **2a** as $\mathbf{D_1}$. The distance from the truck center of truck **36** to articulation connection **26**, namely the cantilever distance, is shown as $\mathbf{D_2}$. The distance from articulation connection **26** to the truck center of truck **40** is indicated as $\mathbf{D_3}$. The distance between the truck centers of trucks **36** and **40**, when car **20**

is sitting on tangent (i.e., straight) track is indicated as $\mathbf{D_4}$. The truck arrangement is asymmetric relative to articulation connection **26**. That is, $\mathbf{D_1}$ is not equal to the distance between truck **38** and articulation connection **26**, (as it would be, for example, with a conventional shared truck located beneath the articulated connector, symmetrically between two rail car bodies). The difference in distance is the length of cantilever **41**, that is, $\mathbf{D_2}$. Similarly, in the illustrated embodiment of Figure **2a**, $\mathbf{D_3}$ equals $\mathbf{D_1}$ plus $\mathbf{D_2}$, although in the general case this need not be so.

As noted above, the cantilever distance $\mathbf{D_2}$ is measured from (a) the pivot connection of truck **36** (that is, the truck center of truck **36**) to (b) the pivot axis, **CL - Pivot**, of articulation connection **26**. As is evident, the pivot axis is neither longitudinally co-incident with the truck center of the nearest adjacent truck, namely truck **36**, nor is it carried over the body of truck **36**, nor over any other truck. Rather, not only is the pivot axis, **CL - Pivot**, longitudinally eccentric relative to the closest truck center, namely that of truck **36**, but moreover, it is cantilevered longitudinally outboard of axle **44**, and of truck **36** entirely. The structure of car body **46** is such as to permit the vertical shear load passed from second rail car unit **24** through articulation connection **26** to be carried to truck **38**.

In the embodiment illustrated in Figure **2a**, a rigid center sill **45** is mounted to car body **46**, and runs longitudinally inboard above truck **36**. Generally, the center sill can be either (a) a through center sill extending fully from articulated connection **26** to coupler **47** at the distal end of first car unit **22**, running above both truck **36** and truck **38**; or (b) alternatively, it can be a stub center sill, as may be advantageous to permit a well to be defined between first and second ends **28** and **30**, with another stub sill being mounted over truck **38** and extending outwardly thereof to a distal end having releasable coupler **47** mounted thereto. Coupler **47**, and all other releasable couplers described herein, are of a type such as to permit, for example, interchangeable service with rail road freight cars in general service in North America. Similarly, rail car unit **24** has a rigid straight-through center sill **49** running inboard of a releasable coupler **47**, above truck **40**, to articulation connection **26**.

Articulation connection **26** (and the other articulated connections noted herein) is preferably a steel articulated connector, indicated generally in Figure **2c** as **50**, similar to those commonly available from manufacturers such as Westinghouse Air Brake (WABCO) of Wilmerding Pa., or American Steel Foundries (ASF), also known as Amsted

Industries Inc., of Chicago Il. The general form of one type of articulated connector (with a vertical pin) is shown, for example, in US Patent 4,336,758 of Radwill, issued June 29, 1982. In general, this kind of permanent, articulated connection has a female member, in the nature of a female socket **52** mounted to a center sill of one articulated rail car unit (in this instance center sill **45** of unit **22**), and a male member **54** mounted to an adjacent rail car unit, (in this instance center sill **49** of unit **24**), as shown in Figure **2c**. Figure **2c** is not necessarily to scale, and may not show all detail features of an articulated connector. It is provided for the purposes of conceptual illustration.

Male member **54** has an extension, or nose, **56** that seats in female socket **52**. A main pivot pin **58** extends through a bore defined in top plate **60** of socket **52**, through a bore, or passage **62** in male member **54**, and through the base plate **64** of female socket **52**. Pivot pin **58** is nominally vertical. That is, on straight, level track pin **58** is vertical. In a conventional arrangement in which the articulated connection is mounted over a truck, another pin may extend from blind bore **65** of pin **58** to seat in the central bore in the truck center plate. Notably, in the embodiment illustrated in Figure **2b**, pin **58** is not supported over a truck.

Male member **54** has three rotational degrees of freedom relative to female socket **52**. First, it can yaw about the main pivot axis, as when the car units negotiate a bend or switch. Second, it can pitch about a transverse horizontal axis, as when the car units change slope at the trough of a valley or the crest of a grade. Third, the car units can roll relative to each other, as when entering or leaving super-elevated cross-level track, (that is, banked track). It is not intended that male member **54** have any translational degrees of freedom relative to female socket **52**, such that a vertically downward shear load **V** can be transferred from male member **54** into female socket **52**, with little or no longitudinal or lateral play. To permit these motions, female socket **52** has spherical seat **66** having an upwardly facing bearing surface describing a portion of a spherical surface. Another mating spherical annular member **68** sits atop seat **66**, and has a mating, downwardly facing, bearing surface describing a portion of a sphere such that a spherical bearing surface interface is created. Member **68** also has an upwardly facing surface upon which male member **54** sits. An insert **70** has a cylindrical interface lying against pin **58**, and a spherical surface that engages a mating spherical surface of passage **62** lying on the inside face of nose **56**. A wedge **72** and wear plate **74** are located between nose **56** and the inner wall, or groin, **76**, of female socket **52**. Wear plate **74** has a vertical face bearing against wedge **72**, and a spherical face bearing against a mating external spherical face of nose **56**. Wedge **72** bears against wear plate **74**,

as noted, and also has a tapered face bearing against a corresponding tapered face of groin **76**. The tapers are formed such that as wear occurs, gravity will tend to urge wedge **72** downwardly, tending to cause articulated connector **50** to be longitudinally slackless.

In the example of Figures **2a** and **2b**, it is preferred that male member **54** be mounted to the end of the center sill (e.g., **49**) of the car unit end that does not have a truck, such as end **32** of car unit **24**, and that female socket **52** be mounted to center sill **45** of the two-truck car unit **22**. In this way the vertical shear from car unit **24** is transferred into the cantilevered overhang of car unit **22** through the spherical interface. By way of an alternative, it appears that in principle, male member **54** could be mounted inversely on car unit **22**, and female socket **54** could be mounted inversely on car unit **24**, with appropriate changes in the location and orientation of the annular members and spherical interfaces, and in the operation of the wedge and wear plate. However, for simplicity, it is advantageous to use existing articulated connectors, installed in the upright orientation addressed above.

The scope of the allowable roll of one car unit relative to the next adjacent car unit is limited by a pair of side-bearing arms **61**, **63** mounted to rail car unit **22**, and mating side-bearing arms **65**, **67** mounted to rail car unit **24**. In Figures **2a** and **2b**, side bearing arms **61**, **63** and **65**, **67** are shown at a higher elevation than articulation connection **26**. This is done for the purposes of conceptual illustration only. In general, side bearing arms tend to be mounted at a height at which their bearing interfaces lie in, or are roughly level with, the horizontal plane (when the cars units are sitting on straight, level track) passing through the center of curvature of the spherical surfaces of the articulated connector. All of the rail road car embodiments described herein employ side-bearing arms, the side bearing arms of the adjacent first and second rail car units being mutually engaging. The side bearing arms have been omitted, for clarity, from Figures **3a** to **5e**, **6a**, **6f**, and **7a** to **8b**.

In the embodiment of Figure **3a**, an articulated rail road car **80** has first, second, and third rail car units **82**, **84**, and **86**. Rail car units **82** and **84** are joined together by an articulation connection **88**, the female portion, or socket being mounted to unit **82**, and the male portion being mounted to unit **84**. Rail car units **84** and **86** are also joined together by an articulation connection **90**, the female portion of connector **90** being mounted to unit **84**, and the male portion being mounted to unit **86**. Rail car unit **82** is substantially the same as rail car unit **22** described above. Rail car unit **84** is substantially the same as rail car unit **24** described above, but has articulation connections mounted at both ends, namely **88** and **90**. Rail car unit **86** is substantially the same as rail car unit **24**.

It will be understood that additional rail car units having articulation connections at both ends, such as rail car unit **84**, can be added intermediate rail car end units having one releasable coupler end, such as rail car units **82** and **86**, to yield a longer string of rail car units. A four-unit rail road car having a further intermediate unit **84**, example is shown in Figure **4a** as **92**. A 5-unit rail road car having three intermediate units **84** is shown in Figure **5a** as **94**.

In the embodiment of Figure **3b**, an articulated three-pack rail road car is indicated generally as **100**. It has a middle unit **102** and a pair of first and second end units **104** and **106**. Middle unit **102** is substantially similar to unit **22** described above. However, it differs in having cantilevered articulation connections **26** mounted at both ends of a through center sill **108**. Each of end units **104** and **106** is a single truck unit substantially the same as unit **24** described above. Middle unit **102** is a two truck unit, and can be thought of conceptually as a car unit made up of two articulation connection ends joined together. Each of the ends of unit **102** has a female portion of respective articulations connection **26**, the corresponding male portions being mounted on units **104** and **106**. Articulation connections **26** are mounted longitudinally outboard of respective first and second two-axle, four wheel swivel mounted (i.e., pivoting) trucks **112** and **114**. As above, the pivot axis of the articulation connections is thus eccentric relative to the closest respective truck center.

In the embodiment of Figure **3c**, an alternative articulated three-pack rail road car is indicated generally as **120**. It has a middle unit **122** and a pair of end units **124** and **126**. Each of end units **124** and **126** is the same as unit **22** described above. Middle unit **122** is a truckless unit, being supported at the articulation connection **26** at either end. That is, rail road car **120** is free of trucks between the longitudinally inboard trucks **128** and **129** of units **124** and **126** respectively. As above, each articulation connection **26** includes a male portion mounted to car unit **122** and mating with female portions mounted to end units **124** and **126**.

In the embodiments of cantilevered articulation connection shown and described above, in contrast to the shared-truck articulation connection **B30** of rail road car **B20**, and the shared truck articulation connections of rail car **C20**, the articulation points of the articulated connectors of rail road cars **20**, **80**, **100**, and **120** lie to the outside of the track centerline as the rail road car moves along a curve. This is shown, for example, by articulation connection **26** in Figure **1c**, and by articulated connections **26** of rail road car

100 in Figure 1e. This outward position relative to the track centerline locates the outer corners **29** and **31** rail car units **22** and **24** adjacent to articulated connection **26** outboard, closer to $\mathbf{R_3}$. The offset distance, δ_3, of rail road car units **22** and **24** is the same as δ_1 shown for rail car units **B22** and **B24**. The length of car unit **22** exceeds the length of car unit **B22** by the length of the overhang, while tending not to require a reduction in car body width relative to car unit **B22**. Similarly, rail car unit **24** also exceeds the corresponding length of rail car unit **B24** by the same, or roughly the same, overhang distance since the point at which the rail car body centerline of rail car unit **24** crosses over the track centerline longitudinally inboard of articulation connection **26**, indicated roughly as **33** in Figure **1c**, is roughly equivalent to the point at which rail car unit **B24** has articulation connection **B30**. Thus rail car unit **24** is longer than rail car unit **B24**, and yet may tend not to require a reduction in width relative to car unit **B24**.

The comparisons of Figures **1d**, **1e** and **1f**, show a first difference between rail road car **C20** and rail road car **100**. Although the width **'W'** of car unit **102** is the same as car unit **C22**, and the truck center distance, $\mathbf{L_1}$, is also the same, the length of car unit **102** between the points of articulation is greater, being equal to $\mathbf{L_1}$ plus twice the length of the cantilever distance $\mathbf{L_2}$ to the articulation connections **26** at each end of car unit **102**. Whereas the car body length $\mathbf{L_3}$ of rail car unit **C22** is shorter than the truck center distance, $\mathbf{L_1}$, by contrast, the car body length $\mathbf{L_4}$ of rail car unit **102** exceeds the truck center distance $\mathbf{L_1}$ by twice the body overhang dimension, $\mathbf{L_5}$. Notably, while the external corners of car unit **C22** lie well clear on the inside of $\mathbf{R_3}$, the external corners **103** and **105**, and adjacent corners **107** and **109** of car units **104** and **106** respectively, are shown running along $\mathbf{R_3}$. The car body length, ($\mathbf{L_3}$ for car unit **C20**, $\mathbf{L_4}$ for car unit **102**) is a measure of the useful loading length, and is taken in each case as the overall deck length dimension over the endmost lateral cross members, whether end sills or end bolsters, as the case may be, of the rail car unit. In each case, (a) the point of articulation (i.e., the pivot centerline) lies longitudinally outboard of the end sill, or end bolster; and, (b) the end sill or end bolster lies longitudinally outboard of the of the nearest truck center pivot axis.

The comparison illustrations of Figures **1g** and **1h** show a second effect. End car unit **104** is longer than end car unit **C24**, again by the overhang distance, indicated as $\mathbf{L_2}$. For the purposes of simplicity of explanation and illustration, the car bodies in all of Figures **1a** to **1h** have been shown as being rectangular, with no tapering of their ends. Similarly, as illustrated in Figure **1e**, the length of car unit **104** has been chosen such that the distance from the truck center of its single truck to articulation connection **26** between rail car units

102 and 104 is equal to L_1 plus L_2. It is then a matter of geometry that the longitudinal centerline of car unit **104** will fall over the centerline of the track at a "phantom truck center" location, indicated as **117**, located L_1 away from the truck center of truck **115**. In a conventional articulated car unit, such as car unit **C24**, this would be the location of the point of articulation, and hence of a shared truck of a shorter car unit. However, as noted, car unit **104** extends beyond this point of intersection, and the rail car unit centerline diverges from the track centerline. This divergence is called swing-out.

The swing-out of the point of articulation is defined as the distance, measured perpendicular to the track centerline, from the track centerline to the pivot axis of the point of articulation. It is shown in Figure **1g** as ϵ. In a conventional articulated rail road freight car ϵ is nil, since the point of articulation is coincident with the pivot axis of the shared truck, and rides over the track centerline as shown in Figure **1h**.

The outline of the body of rail car unit **104** is shown in Figure **1h** in intermittent dashes and dots, and indicated as **104a**. It has width **'W'**, the same as unit **102**. The outline of the body of rail car unit **104**, as if it had no swing-out (i.e., ϵ = zero) is shown in solid line as **104b**, also being of width **'W'**. As can be seen, the inside edge of **104b** crosses into the impermissible zone lying to the inside of $\mathbf{R_2}$. The narrower outline of the body of rail car **104**, having an ϵ of zero, like **104b**, and having the same length as **104a**, yet remaining outside the $\mathbf{R_2}$ boundary, is shown in dashed lines as **104c**. As can be seen, **104c** is narrower than **104a**. That being the case, and ϵ being very small relative to $(L_1 + L_2)$, taking truck center **115** as a point of rotation, by similar triangles the swing out at articulation connection **26** between rail car units **102** and **104** moves the inside edge of the car at mid span between **115** and **117** radially outward relative to $\mathbf{R_1}$, $\mathbf{R_2}$ and $\mathbf{R_3}$ a distance smaller than, but proportionate to, ϵ. The net effect is that swing-out tends to permit a wider car than otherwise, or to permit a greater car length for the same width as previously used.

In summary, conceptually, placement of the articulation connection longitudinally outboard of the truck centers can be thought of in terms of the additional car length that can be obtained by having an overhang, without changing the width of the car. It can also be thought of in terms of the cantilever arm forcing the centerline of the adjacent car unit outward relative to the radius of curvature of the centerline of the track, such that the adjacent rail car body can be wider than it could be if the articulation were not cantilevered.

Further, although the various embodiments illustrated herein show articulated

connectors mounted to overhang beyond the closest adjacent truck to obtain the full benefit of car length possible within a given car plate envelope, some of this benefit can be obtained from lesser longitudinal eccentricity between the truck center and the pivot center, since even a partial eccentricity will cause the inboard deck edge of the car having the male articulated connection portion to ride further toward the outside of the track than otherwise.

The remaining multi-car embodiments shown in Figures **4b** to **4d** and **5b** to **5e** can be assembled from rail car units of the types described above. For example, the embodiment of Figure **4b** shows an articulated rail road car **130** that has a single-truck first end unit **132** that is the same as end unit **24**; a two-truck intermediate rail car unit **134** that is the same as rail car unit **102**; an intermediate single-truck unit **136** that is the same as unit **84**, and a second single-truck end unit **138** that is the same as unit **24**. Figure **4c** shows an articulated rail road car **140** that has a first two-truck end unit **142** that is the same as unit **82**; a truckless intermediate unit **144** that is the same as truckless unit **122**; a two truck intermediate unit **146** that is the same as unit **84**; and a single truck end unit **148** that is the same as unit **24**.

It is also possible to join adjacent rail car units with a combination of slackless draw bar connections and articulation connections. For example, in the embodiment of Figure **4d**, a partially articulated, partially draw-bar connected rail road car assembly **150** has a pair of two truck intermediate units **152** and **153** that are similar to unit **102**, and a pair of single truck end units **154** and **155** that are similar to unit **24**, but rather than having an articulated connection, units **152** and **153** are joined at their adjacent ends by a draw bar connection, indicated schematically as **156**. Where a draw bar is used, there is an adjacent rail car truck **157**, **158** supporting the near end of each or the adjacent rail car units **152**, **153** lying to either side of the draw bar. It would be possible, alternatively, to make a four-unit articulated rail road car by joining two pairs of rail road car units, such as **22** and **24**, at the truck ends of their single truck rail car units, (i.e., **24**) with a drawbar in place of releasable coupler **47**.

In Figure **5b**, an articulated rail road car **160** has an interior two-truck rail car unit **162** that is the same as unit **102**, one single-truck end unit **164** connected to one end of unit **162**, unit **164** being the same as unit **24**; two intermediate units **166**, **167** that are the same as unit **84**, and a further single-truck end unit **168** that is the same as unit **24**.

In the embodiment of Figure **5c**, an articulated rail road car **170** has an interior,

middle two-truck unit **172** that is the same as unit **102**, a pair of first and second oppositely oriented intermediate single-truck units **174**, that are each the same as unit **84**, and a pair of first and second single-truck end units **176** that are the same as unit **24**. In the embodiment of Figure **5d**, an articulated rail road car **180** has an internal two-truck middle unit **182** that is the same as unit **102**, a pair of two-truck end units **184** that are the same as unit **22**, and a pair of intermediate truckless units **186** that are the same as unit **122**. In the embodiment of Figure **5e**, an articulated rail road car **190** has a pair of first and second oppositely oriented single-truck end units **192** that are the same as unit **24**, a pair of intermediate two-truck units **194** that are the same as unit **102**, and a middle, truckless unit **196** that is the same as unit **122**. Other combinations and permutations of these rail car units are possible.

Other multi-unit articulated rail road cars, or partially articulated rail road cars, having a larger number of rail car units can be assembled from the various types of rail car units noted above, whether one truck, two-truck, or truckless, and whether they are end units or intermediate units. In general, in each example there is an articulated rail road car having a plurality of rail car units, supported on a suitable number of rail car trucks to permit the articulated rail road car to roll in a longitudinal direction on rail road tracks. In each case there is at least one articulation connection lying between a pair of adjacent, first and second rail car units, the articulation connection being longitudinally cantilevered relative to the nearest of the rail car trucks. That is, none of the rail car trucks is mounted centrally under the cantilevered articulation connection.

Figure **6a** shows a two-unit articulated auto rack rail road car **200** that is similar to articulated rail road car **20** in layout. It has a two-truck first unit **202** and a single truck second rail car unit **204**, joined at an articulation connection **206**. Unit **202** has first and second end portions **208** and **210**, each of which is mounted over a freely pivoting four wheeled truck **212**, **214** respectively. First end portion **208** is proximate to connection **206**, and second end portion **210** is distant from connection **206**. Second end portion **210** has a conventional releasable coupler **215** mounted thereto for connection to other cars in interchangeable service.

Unit **204** has first and second end portions **216** and **218**, end portion **216** being proximate to connection **206** and end portion **218** being distant therefrom. Unit **204** has a single freely pivoting four-wheeled truck **220** located under end portion **218**. Second end portion **218** is substantially the same as second end portion **210**, and, similarly, has a

conventional releasable coupling **215** for interchangeable service. In this way, two-truck rail car unit **202** is a two-truck end unit, and rail car **204** is a single truck end unit.

Each of units **202** and **204** has a body **222, 223** having an upwardly extending enclosure structure for housing vehicles to be carried, such as automobiles, indicated generically as **224, 225**. A decking structure **226, 227** is mounted within body **222, 223**. In the embodiment illustrated in Figure **6a**, decking structure **226, 227** is a triple deck structure that includes a flat main deck **228, 229**, an upwardly spaced middle deck, **230, 231** and a further upwardly spaced upper, or top deck **232, 233**. A spanning assembly in the nature of main, middle and top pairs of bridge plates **234, 235, 236** extend between decking structures **226** and **227** to permit longitudinal loading of vehicles from one car unit to the next in the manner known as circus loading. The gap between enclosure structures **224** and **225** is enclosed by a flexible structure in the nature of a bellows **238**. The open ends of enclosure structures **224** and **225** and enclosed by moveable closure members in the nature of doors **240, 241**, typically of the type often referred to as a "radial arm door" employing a monolithic door panel having a curved portion and a tangent portion and a radial arm extending from a point of rotation to the door panel. The doors are moveable between open positions for loading and discharging vehicles, to a closed position tending to keep out rain, snow, stones, vandals and thieves.

Details of autorack rail car **200** of Figure **6a** are illustrated generally in Figures **6b**, and **6c**, with the upper and middle decks, bridge plates, bellows and side panels removed. Each of car units **202** and **204** has a main center sill **242, 243**; a pair of left and right hand side sills **250, 252** and **251, 253**; and an array of cross-bearers **254, 255** extending laterally between center sill **242, 243** and side sills **250, 252, 251, 253** at the longitudinal stations of an array **256, 257** of upright posts **258, 259**.

Posts **258, 259** are, typically, on roughly 4 ft centers. Posts **258, 259** extend upwardly to a top chord member **260, 261**, to which a roof canopy of transversely corrugated steel sheet **262** is mounted. Each of posts **258, 259** is provided with a gusset plate **264** to improve the moment connection to side sill **250, 252** or **251, 253**, respectively. The last, or most longitudinally outboard of posts **258** or **259** is sometimes referred to as the "number 1" post indicated as **263**, and the penultimate (i.e., second to last) post, namely the next longitudinally adjacent inboard post is referred to as the "number 2" post, indicated as **265**. A diagonal brace **266** extends upwardly from the base of the "number 1" post **263** toward the juncture of the "number 2" post **265** with each respective top chord. An end post, **268**,

extends between the deck and canopy sheet **262** outboard of "number 1" post **263**.

Car unit **202** has a laterally extending main bolster **270** mounted at the longitudinal location of the truck center of truck **212**, such that the laterally outboard distal extremities of main bolster **270** meet side sills **250**, **252** at the longitudinal station of the root of the "number 2" post, **265**. An endmost lateral structural member in the nature of an end bolster **272** extends laterally outboard from main center sill **242** to meet the ends of side sills **250** and **252**. (In this, or other, examples, the endmost lateral structural member can be either an end bolster or an end sill, or other suitable cross-member). A main deck shear plate **274** is mounted upon the upper flanges of main center sill **250**, main bolster **270**, end bolster **276** and cross-bearers **254** and extends laterally between side sills **250**, **252**. At the longitudinally outboard end portion **210** of car unit **202**, that is, the end furthest from articulated connection **206**, rail road car **200** has a similar underframe construction of main bolster, end bolster and cross-bearers and shear plate. It differs in having a conventional draft sill and releasable coupler **215** for interchangeable service connection with other rail road cars. The upper portion of Figure **6b** is shown with the respective shear plates removed to reveal the underlying bolster structure.

Rail car unit **204** has a conventional underframe structure at its longitudinally outboard end portion, **218**, with main bolster, end bolster, cross bearers, shear plate, draft sill and interchangeable coupler in the same manner as end **210** of unit **202**. At the inboard end portion **208** of car unit **204**, the underframe structure differs in having merely an end bolster **278**, and cross-bearers **280**, but no main bolster, and a straight through main sill end of constant section to the end bolster, there being no truck to be accommodated.

A female articulated connector portion **282** is mounted to the end of center sill **242** of car unit **202**. A male articulated connector portion **284** is mounted to the inboard end of main center sill **243** of rail car unit **204**, portions **282** and **284** being designed to mate and to be held together with appropriate bearing surfaces and a pin, such as described above. Female articulated connector portion, **282**, is bracketed by a pair of left and right hand female side-bearing arms **286**, **288**. Arms **286** and **288** are splayed outwardly. Longitudinal structural reinforcement members, in the nature of a pair of first and second left and right hand beams **290**, **292** are carried longitudinally inboard from the root of arms **286** and **288**, to terminate at main bolster **270**.

Male articulated connector portion **284** is bracketed by a pair of left and right hand

male side bearing arms **287** and **289**. Arms **287** and **289** are splayed outwardly. Longitudinal structural reinforcement members, in the nature of a pair of first and second, left and right hand beams **291**, **293** are carried longitudinally inboard from the root of arms **287** and **289**, to terminate at the second inboard cross-bearer located at the longitudinal station of the "number 2" post **265**, indicated as **290**.

Side bearing arms **286**, **288**, and **287**, **289** engage in the manner of side bearing arms generally, with female arms **286** and **288** having upwardly facing bearing surfaces **292**, **294**, and male side bearing arms **287**, **289** having downwardly facing bearing surfaces **293**, **295**. The arrangement of the male and female bearing surfaces could be reversed. However, in operation this reversal could tend to increase the vertical reaction carried in the female portion **282** of articulated connector **286**, whereas the arrangement shown would tend not to.

Figure **6d** shows a cross-section of car unit **202** at the truck center of truck **212**, and shows a tri-level configuration of main, middle and upper decks **228**, **230** and **232** for carrying automotive vehicles. Each of the middle and upper decks has a slight crown, and has knee braces **296** mounted to posts **258**. Figure **6e** shows a similar cross section of an alternative car unit in a bi-level configuration, with a main deck **228** and an upper deck **298**. A thin-shelled corrugated steel roof structure **299** is shown mounted to span the width of car unit **202** above the decks between the top chords.

In the alternative embodiment of Figure **6f**, another two unit, articulated auto-rack rail road car is indicated as **300**. It has first and second units **302** and **304** that are broadly similar to units **202** and **204**, but differs from them in having wells **305**, **307** located inboard of trucks **306**, **308** and **310** between respective pairs of side sills **312**, **314**, rather than a flat main deck. The body of each of units **302** and **304** employs a truss structure **316**, **318** having a substructure that includes side sills **312**, **314**, a superstructure that includes an overhead framework **320**, **321** having transverse frames and longitudinal stringers, and an intermediate shear force transfer assembly in the nature of pairs of laterally spaced side webworks **322**, **323**. Each of side webworks **322**, **323** includes an array of posts **324**, **325** and diagonal bracing **326**, **327**. Side web works **322**, **323** extend vertically between side between the substructure and a pair of top chord members **328**, **329**. The transverse frames of overhead framework **320**, **321** are mounted on top chord members **326** at the longitudinal stations of posts **324**. In this way the superstructure, substructure, and intermediate shear force transfer assemblies co-operate, and tend to function in the manner of a box truss.

In further alternative embodiments, units **202** and **204** could be made using a similar truss construction to units **302** and **304**, or, conversely, units **302** and **304** could be fabricated with a thin-shelled roof structure as shown in Figures **6b**, **6d** and **6e**.

Inasmuch as the cross-section of autorack rail car units **202** and **204** is the same at mid span, a car unit having two trucks, and articulation connections at each end can be manufactured by using two end portions **208**, as shown in Figure **6b**, **6c** mounted to form a single body. Alternatively, a truckless car unit can be manufactured using two truckless end portions, such as end portion **216**, in a single body, and an internal single truck car unit can be manufactured using an end portion such as end portion **208** of unit **202** and an end portion such as end portion **216** of unit **204**, mounted together to form a single body. In this way, a variety of types of car can be produced to yield the various strings of cars units described below.

Figure **7a** shows a three-pack articulated auto rack rail road car **330** having the same general layout as articulated rail road car **80** of Figure **3b**. Rail road car **330** has a truckless middle unit **332** and a pair of two-truck end units **334** and **336**. Each of end units **334** and **336** has the same construction as unit **202** of articulated rail road car **200** described above. Unit **332** however, is truckless. That is, unit **332** is supported at either end at articulation connections **338** and **340**, but is not otherwise supported by any truck between trucks **342** and **344** of units **334** and **336**. Conceptually, unit **332** can be thought of as having two end portions **346** and **348**, each of which is like end portion **216** of car unit **204**, joined together.

Figure **7b** shows a three-pack articulated auto-rack rail road car **350** that has the same general layout as articulated rail road car **100** of Figure **3a**. That is, it has a two-truck middle unit **352**, and a pair of single truck end units **354** and **356**. Each of units **354** and **356** has the same construction as auto-rack rail car unit **204**. Rail car unit **352** has a pair of freely pivoting trucks **358** and **360** and articulated connectors at both ends. The general construction of car units **352**, **354** and **356** is as described above for car units **202** and **204**.

Rail road car **350** shows the preferred truck layout of the present invention – that is, an articulated three pack auto rack rail road car with a two truck middle unit, with single truck end units to either side, and cantilevered articulated connectors lying outboard of the respective trucks of the middle car unit. Although the rail road cars of Figures **7a**, **7b**, **8a** and **8b** are shown in tri-level configuration, it will be understood that they can be made in

either bi-level configuration, or tri-level configuration, or with movable decks convertible between bi-level and tri-level configurations. In the preferred embodiment, the decks are fixed, and in bi-level configuration as shown in Figure **6c**. In the preferred embodiment, in bi-level configuration, the spacing between the truck centers of the two-truck middle car unit is 57 ft. 9 in., that is, a distance greater than the base car truck center distance of 46 ft. 3 in. The distance from the nearest truck center to the articulated connector is 12 ft. 1 in. The distance between the articulated connectors is then 81 ft. 11 in. The distance from the articulated connection to the adjacent single end unit truck at either end is 69 ft. 10 in. with a 14 ft. 1 in. overhang to the striker face. The overall length of the three pack is 249 ft 9 in., such that a pair of three pack cars coupled together yields a nominal design length of 499 ft 6 in. An example of dimensions for a corresponding tri-level three-pack auto rack rail car are 55' - 0" truck centers for the two truck middle car unit; truck to articulation, 8 ft, 3.5 in.; between articulations 71 ft. 7in.; from the articulations to the single end unit trucks is 58 ft. 6 in.; the end unit overhang is 13 ft. 7 - 3/4 in.; and the overall tri-level three pack length is approximately 218 ft.

Figure **8a** shows a four unit articulated auto-rack car **370**. It has individual single truck rail car end units **372**, **373**, and internal double truck rail car units **374**, **375**. End car units **372** and **373** have the same layout and construction as car unit **204** of Figure **6a**. Internal car units **374** and **375** have the same general construction as car unit **202** of Figure **6a**, but rather than having a releasable coupler at the end remote from their respective single truck adjacent units, car units **374** and **375** are connected at their common end by a slackless draw bar **378**.

Figure **8b** shows another four unit articulated auto-rack rail road car, **380**. It has a two truck end rail car unit **382** of the same construction as two truck end unit **202** of Figure **6a**; a single truck end unit **384** that has the same construction as single truck end unit **204**, a two truck intermediate unit **386** that has the same construction as middle unit **352**, and a truckless intermediate unit **388** that has the same construction as middle unit **302**, described above.

The end portions of the car units shown in Figures **6a** to **6f**, **7a** and **7b** and described herein can be assembled to produce single truck rail car end units, single truck intermediate rail car units, truckless intermediate units, two truck intermediate units, and two truck end units. In that light, the car units described can be assembled and arranged to produce many other combinations of rail road cars having cantilevered articulations, whether 2, 3, 4, 5, 6, 7

or more units in an articulated rail road car, including auto rack rail road cars corresponding to each of the examples of Figures **2a** to **5c**. Further, the general construction of either the units of rail road car **200** or of rail road car **300** can be employed. In addition, although the above description applies to multi-level auto-rack cars, it can also be applied to single deck articulated rail road cars for carrying vehicles. A single deck articulated rail road car, without side wall structures, and without an overhead roof structure can also be constructed, such as for carrying larger vehicles, highway trailers or other intermodal cargo.

Figures **9a**, **9b**, **9c** and **9d** show abridged top and side views of two units of an articulated well car **400** such as may be employed for transporting intermodal containers or highway trailers, or a combination of containers and highway trailers. Figures **9a**, **9b**, **9c** and **9d** have been abridged to omit the central portions of the units of car **400**, so that the end portions may be shown in a larger proportion. The views are truncated longitudinally inboard of the first container support cross-member, the cross-section of the car between those cross-members being constant, with transverse cross-members spaced longitudinally to provide support for the various containers support pedestals or cones, or highway trailer rear wheel sets as required conventionally.

Rail road car **400** has a first end unit **402**, and a second end unit **404**, joined at an articulated connection **406** that has a first, or female portion **408** mounted to first end unit **402**, and a second, or male portion **410** mounted to second end unit **404**. Portions **408** and **410** engage, and when mated, are held together by a nominally vertical pin, as noted above.

First end unit **402** is a two-truck end unit, having a first end portion **412** proximate to articulation connection **406**, and a second end portion **414** distant from connection **406**. A first, freely pivoting two axle rail car truck **416** is mounted under second end portion **414**. Another freely pivoting two axle rail car truck and **418** is mounted under first end portion **412**. Inboard truck **418** has larger wheels, and a larger carrying capacity, than outboard truck **416**. That is, outboard truck **416** has 33 inch diameter wheels. Inboard truck **418** has 38 inch wheels.

The distal end, that is, the longitudinally outboard end of portion **414** carries a standard releasable coupling (not shown) for connection with the couplers of other rail cars in interchange service.

Rail car unit **402** has structural longitudinal central beam members in the nature of a

first, outboard stub center sill **420**, and a second, inboard stub sill **422**. It also has transverse structural members in the nature of a first; outboard main bolster **424** (shown in hidden lines) extending perpendicularly laterally from outboard stub sill **420** at the longitudinal location of the truck center of outboard truck **416**; an inboard main bolster **426** extending laterally perpendicular to inboard stub sill **422** at the location of the truck center of inboard truck **418**; a first end bolster **428** located parallel to, and longitudinally outboard of, first main bolster **424**; a second end bolster **430** located parallel to, and longitudinally outboard of second main bolster **426** (that is, toward articulation connection **406**). A pair of laterally spaced, deep side sills **432** and **434** extend the length of rail car unit **402** between end bolsters **428** and **430**, and mate also with the outboard ends of the wings of main bolsters **424** and **426**. Outboard stub center sill **420** has an inboard termination at a transverse bulkhead **436** that extends between side sills **432** and **434**. Similarly inboard stub center sill **422** has an inboard termination at a transverse bulkhead **438**, also extending between side sills **432** and **434**.

It can thus be seen that a well **440** is defined between side sills **432** and **434**, and longitudinally between bulkheads **436** and **438**. Well **440** is provided with cross members **442** extending between side sills **432** and **440**, the cross members having container supports members or pedestals **444**. Floor pans **446** are also provided for supporting the wheel sets of highway trailers, as may be required.

A pair of pin-jointed diagonal load spreading beams **448** and **450** extend between a footing **452** whence loads are passed to and from stub center sill **420**, to inboard terminations mounted to first cross beam **454**. A shear plate **456** overlies the cruciate form of stub center sill **420** and main bolster **424** and extends to side sills **432** and **434**. A hitch mounting, to which a highway trailer hitch plate can be pivotally affixed is shown as **456**. Hitch mounting **456** is located over the longitudinal centerline of unit **402**, at the longitudinal station of main bolster **420**.

Similarly, at the far end of well **440**, a pair of pin-jointed diagonal load spreading beams **449** and **451** extend between a footing **453** whence loads are passed to and from inboard stub center sill **422**, to inboard terminations mounted to first cross beam **455**. A shear plate **457** overlies the cruciate form of stub center sill **422** and main bolster **426** and extends to side sills **432** and **434**. A hitch mounting, to which a highway trailer hitch plate can be pivotally affixed is shown as **459**. Hitch mounting **459** is located over the longitudinal centerline of unit **402**, over main bolster **422**.

portion **406**. Reinforcements, that is, a pair of longitudinally extending stiffening members in the nature of steel beams **484** and **486**, are mounted intermediate stub center sill **426** and side sills **432** and **434**, respectively, such that they mate with end bolster **430** at the lateral station corresponding to the root of each of side bearing arms **480, 482**. Beams **484, 486** run inwardly to terminate at main bolster **426**. Gussets are located opposite the webs of beams **484, 486** to provide web continuity at the junctions with main bolster **424** and end bolster **428**. It will be noted that side bearing arms **480, 482** have bearing surfaces **490, 492** that face upwardly. A brake valve mounting bracket **494** extends from side bearing arm **492**.

Car unit **404** is shown in Figure **9c** and **9d** in abridged top and side views. Car unit **404** has a distal end portion **500** located away from articulated connection **406**, and a proximal end portion **502** to which male articulated connector portion **410** is mounted. Distal end portion **500** is substantially identical to distal end portion **420** of first rail car unit **402**, described above, the same item numbers being used to identify the various components.

Proximate end portion **502** is significantly different in construction to end portion **412** of unit portion **402**. End portion **502** has a main structural longitudinal central beam member in the nature of a first, inboard stub center sill **503**. End portion **502** has transverse structural members in the nature of an end bolster **506** located at the end of stub sill **503** immediately adjacent male articulated connector portion **410** and running laterally outboard to side sills **508** and **510**; and a second inboard end bolster cross-member, or bolster **512** located parallel to, and longitudinally inboard of, end bolster **506** (that is, in a longitudinal direction away from articulation connection **406**). Inasmuch as unit **404** does not have a truck at proximal end portion **502**, it does not have a main bolster with a fitting to mate with a truck. It also does not have a wheel well, or side sill rebate. Rather, side sills **508** and **510** continue at full depth to a vertical corner post **516**. Stub center sill **503** has an inboard termination at a transverse bulkhead **515** that extends between side sills **508** and **510**.

It can thus be seen that a well **520** is defined between side sills **508** and **510**, and longitudinally between bulkheads **516** and **515**. Well **520** is provided with cross members **522** extending between side sills **508** and **510**, the cross members having container supports members **424**. Floor pans **426** are also provided for supporting the wheel sets of highway trailers, as may be required.

As described above in the context of rail car unit **402**, a pair of pin-jointed diagonal load spreading beams **528** and **530** extend between a footing **532** whence loads are passed to

Each of side sills **432** and **434** has a middle portion **431** of constant depth, and end portions **433** and **435** of reduced depth to clear the respective trucks. The top chord member **437** of each of side sills **432**, **434** is carried through the full length of the car. The bottom chord member **439**, and the web member **441** connecting top chord member **437** and bottom chord member **439**, are both cut short to accommodate the trucks, **416** and **418**. The wheel rebate **443** so formed is bordered by an upswept flange, or fender **445** that sweeps upwardly on a curve from bottom chord **439** at the end of middle portion **431**. A tapered hollow longitudinal reinforcement beam **447** is mounted above, and runs along, each of top chord members **437** between the respective end bolster and well **440**, giving a greater depth of section to end portions **433** and **435**

The end portion **414** of rail car unit **402** is constructed in the manner of a rail car termination end for interchangeable connection with other railroad cars generally. By contrast, end portion **412** of rail car unit **402** is an internal end to which an articulated connector portion, namely female articulated connector portion **470** is mounted. Female articulated connector portion **470** is mounted in a pocket formed between the upstanding side webs, and the bottom flanges of the longitudinally outboard extending end of stub center sill **420**, and a false flange, or web, welded inside center sill **420** below the level of shear plate **457**.

As shown in the side view of Figure **9b**, center sill **420**, side sills **432** and **434**, and shear plate **457** all extend longitudinally outboard of the longitudinal station of the truck center **CL - Truck**, of truck **418**, such that there is a cantilevered overhang, indicated generally as **464**, to which the connection means, namely female connection portion **460** is welded. Truck **418** has an inboard axle **466**, an outboard axle **468**, side frames **470**, and a truck bolster **472** that lies under main bolster **426**. As can be seen in Figure **9b**, the center pin axis **CL - Pivot**, defining the location from which articulation connection **406** is measured, is located outboard of the distal extremity of overhang **464**. The longitudinal offset is the distance between **CL – Pivot** and **CL - Truck**. Not only is the pivot centerline, and hence connection **406** longitudinally eccentric relative to the truck center, but it is cantilevered outboard a distance lying beyond the axis of outboard axle **468**, lies fully outboard of truck **416** generally, and lies outboard of the endmost lateral structural member, namely end bolster **430**, as well.

A pair of inverted side bearing arms **480** and **482** are mounted to, and extend longitudinally outboard from, end bolster **430** to bracket female articulated connection

and from stub center sill **503**, to inboard terminations mounted to first cross beam **534**. A shear plate **536** overlies the H-shaped form of stub center sill **503**, end bolster **506** and inboard bolster **512**, and extends to side sills **508** and **510**. A hitch mounting, to which a highway trailer hitch plate can be pivotally affixed is shown as **538**. Hitch mounting **538** is located over the longitudinal centerline of unit **404**, between bolsters **506** and **512**.

In summary, the end portion **500** of rail car unit **404** is constructed in the manner of an external rail car termination end for interchangeable connection with other railroad cars generally. By contrast, end portion **502** of rail car unit **404** is an internal end to which an articulated connector portion, namely male articulated connector portion **410** is mounted. Male articulated connector portion **410** is mounted in a pocket formed between the upstanding side webs; and the bottom flanges of the longitudinally outboard extending end of stub center sill **503**, and a false flange, or web, **544** welded inside center sill **503** below the level of shear plate **546**.

A pair of side bearing arms **550** and **552** are mounted to, and extend longitudinally outboard from, end bolster **506** to bracket male articulated connection portion **410**. Reinforcements, that is, a pair of longitudinally extending stiffening members in the nature of steel beams **554** and **556**, are mounted intermediate center sill **503** and side sills **508** and **510**, respectively, such that they mate with end bolster **506** at the lateral station corresponding to the root of each of side bearing arms **550** and **552**. Beams **554** and **556** run inwardly to terminate at bolster **512**. Gussets are located opposite the webs of beams **554** and **556** to provide web continuity at the junctions with bolster **512** and end bolster **506**. It will be noted that side bearing arms **550** and **552** has bearing surfaces **560** and **562** that face downwardly to permit engagement with the upwardly facing bearing surfaces **490** and **492** of unit **402** when articulated connector portions **408** and **410** are engaged and car **400** is operated on a bend.

When male portion **410** engages female portion **408**, a vertical shear load from unit **404** is transferred to the cantilever formed by stub sill **420**, and the associated overhanging end structure **464** of unit **402**. The vertical reaction to this force is provided by truck **418** acting through second main bolster **426** of unit **402**. The bending moment in sill **422** at the truck center location of truck **418** is balanced by the weight of car unit **402** lying toward truck **416**.

Although end portion **502** of unit **404** does not have a truck, and although male

articulated connector portion **540** is not supported directly over a truck, and although side bearing arms **560** and **562** are not reacted by side bearing arm pedestals mounted on a truck, but rather by side bearing arms **490** and **492**, vertical weight tends to be carried by the female articulated connector portion **408** in the same manner as if it were carried above an articulated truck. That is, from the male side of the connection, the load transfer may tend to appear to be unchanged.

Although rail car unit **404** is shown as a single unit end truck, having a single internal male articulated connector portion at the unsupported internal end (namely end **502**), and rail car unit **402** is shown as a single unit two-truck end unit having a single internal female end, other combinations are possible. For example, as suggested by the foreshortening abridgement section of Figures **9a**, **9b**, **9c** and **9d**, two internal male ends, such as end portion **502**, can be assembled to yield a truckless car supported only at the permanent male articulated connector fittings at either end of the car. Such an internal car could be used as the middle car in the embodiment of Figure **3c**, for example. Similarly, an internal car with female articulated connector portions can be made by assembling two ends such as proximate end portion **412** of Figures **9a** and **9b**. Such a car can be used as the middle car unit in a layout such as described in Figure **3b**. Thirdly, a single truck intermediate car unit can be manufactured by combining the proximate end portion **502** of car unit **404** with the proximate end portion **412** of car unit **402**. In this way, all of the combinations of layout noted above can be assembled using combinations of the end portions shown and described in Figures **9a**, **9b**, **9c** and **9d**. In this way the construction shown and described permits the manufacture of the sets and combinations of layout of articulated rail road cars shown in Figures **2a** to **5e**. It will also be noted that flat cars, or auto-rack cars, or box cars, or other types of cars can be assembled using the same type of construction as described in Figures **9a**, **9b**, **9c** and **9d**.

Various embodiments of the invention have now been described in detail. Since changes in and or additions to the above-described embodiments may be made without departing from the nature, spirit or scope of the invention, the invention is not to be limited to those specific embodiments.